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THE FATE OF A GELATINE SPONGE INTRODUCED INTO THE FOURTH VENTRICLE. EXPERIMENTS IN DOGS.

by

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Since LIGHT and JENKINS introduced an absorbable gelatine sponge for the purpose of hemostasis in 1945, it has been routinely used in surgery, especially in intracranial surgery. In case of a tumor arising in or invading a cerebral ventricle, we have at times to leave a gelatine sponge in the ventricle after removal of the tumor.

It is said that a gelatine sponge causes only a slight inflammatory reaction in the surrounding brain tissue and is absorbed by the process of organization without excessive scar formation as in the case of other tissues. However a cerebral ventricle appears not a little different from other parts of the brain in the following points; (1) it is covered by the ependymal layer of ectodermal origin, (2) filled with the cerebrospinal fluid and (3) the chorioid plexus is attached to it. How will a gelatine sponge be absorbed in such conditions? If it is absorbed with organization, there are questions as to how the scar is formed following the absorption and whether a residual scar tissue interrupts the cerebrospinal fluid flow.

In order to solve those problems I have inserted a gelatine sponge into the fourth ventricles in dogs and investigated how it is absorbed. I have placed it also on the brain surface or within the brain substance in other groups of dogs for the purpose of comparison.

MATERIALS AND METHODS

Adult mongrel dogs weighing about 10 kg. were used. All the experimental animals were anesthetized with 10 % solution of sodium isoamyl ethylbarbiturate (0.33 cc/kg.), injected into the abdominal cavity, after basic narcosis with 4 % narcocon-scopolamine. Three kinds of gelatine sponge preparations were utilized in this experiment: Spongel (YAMANOUCHI Co. JAPAN), Gelfoam (UPJOHN Co. U.S.A.) and Spongostan (FERROSAN Co. DENMARK).

(I) Insertion of a Gelatine Sponge into the Fourth Ventricle.

After a suboccipital longitudinal incision of the skin was made, extending from the external occipital protuberance to the posterior process of the first cervical spine, the cerebellomedullar cistern and the caudal part of the vermis were exposed. Because the foramen of Magendie is not present in dogs, as Dandy pointed out, a small incision had to be made on the posterior medullary velum at the time of

insertion of a gelatine sponge. A gelatine sponge in dry state was twisted tightly into a string measuring 0.5 cm. in diameter and 2.5 cm. in length and was used for insertion. As there was nearly no difference in specific gravity among the three kinds of preparations, the amount of each gelatine sponge inserted was nearly the same. By elevating the vermis lightly and sucking up the cerebrospinal fluid thoroughly, the rhomboidal fosse, i.e. the floor of the fourth ventricle can be seen. Then a gelatine sponge string was inserted deeply into the fourth ventricle towards the Sylvian aqueduct. As the dural defect was impossible to suture in most cases, it was covered by another piece of the gelatine sponge from outside. After various periods of survival, from 30 to 270 days, the animals were sacrificed by bleeding from arteries. The brains were removed immediately after death and fixed in 10 % formalin solution for two weeks. After macroscopical examination, the hind brain including the inserted gelatine sponge was embedded in celloidin or paraffin. Serial sections were made and stained with the following three methods: hematoxylin and eosin stain, Weigert-Pal's stain for myelin sheath and Mallory's phosphotungstic acid hematoxylin stain for neuroglia.

(II) Insertion of a Gelatine Sponge on the Brain Surface or within the Brain Substance.

a) For comparison, a string of the twisted gelatine sponge of the same size and form was inserted on the brain surface, chiefly on both sides of the superior sagittal sinus to the extent from the upper ridge of the frontal sinus to the internal occipital protuberance. The reason why I selected these regions for insertion was as follows: It was expected that arachnoidal adhesions might be produced by the scar tissue successive to absorption of the gelatine sponge, and due to the resultant disturbance of the flow of the cerebrospinal fluid into the superior sagittal sinus, a hydrocephalus might develop.

b) Insertion of a gelatine sponge within the brain substance was performed in the parietal region, vertically to the brain surface and care was taken not to injure blood vessels as much as possible. In this experiment a string of the twisted gelatine sponge 1.5 cm. long and of the same diameter as in other experiments was used. The animals of a) and b) groups were sacrificed by bleeding from arteries after various survival periods, from 30 to 210 days and from 30 to 90 days, respectively. The brain attached to dura was removed immediately after death and fixed in 10 % formalin solution for two weeks. They were then embedded in celloidin or paraffin, sectioned and examined histologically.

RESULTS

(I) Experiment of Insertion of a Gelatine Sponge into the Fourth Ventricle.

The majority of twenty animals showed vomiting for ten days after the operation. In five animals there were choked discs on both sides, with an elevation of 1 D. to 4 D. Some animals showed cerebellar ataxia and nystagmus, which disappeared by two weeks after the operation. No moter palsy was recognized. Enlargement of the ventricular system of various degree occurred in the majority

of twenty animals. Fig. 1 shows the frontal section at the level of tuber cinereum of the dog No. 32, which survived for 142 days after the insertion of a gelatine sponge into the fourth ventricle. In this figure one will see a remarkable enlargement of the third and the lateral ventricle, as compared with the control brain on the right side of the figure. As the passage of the cerebrospinal fluid from the ventricular system to the subarachnoid space should be interrupted by the cicatricial mass produced in the fourth ventricle after the absorption of a gelatine sponge, it is a matter of course that such an obstructive internal hydrocephalus results. Macroscopically a part of the gelatine sponge inserted preserved spongy structure as long as three months after the operation, but it changed later into a grey fairly dense fibrous tissue. Although the dural defect was covered by another piece of the gelatine sponge in all the animals at operation, it changed into a dense fibrous tissue filling the defect completely. Even in the animals, in which the defect was fairly large, no fluid leakage was evidenced.

Histological Findings :

(1) 31 days after insertion of Spongel into the fourth ventricle. (No. 3, Fig. 2)

The chorioid plexus of the fourth ventricle is seen pushed up towards the cerebellum by the Spongel. The Spongel itself is surrounded by the chorioid plexus on the upper side and by the oblongate medulla on the lower. A thin granulation tissue is seen in the peripheral part of the Spongel, where a few capillary blood vessels and numerous fibroblasts, fibrocytes, connective tissue fibers and lymphocytes are found. Except for its peripheral parts, the Spongel preserves an original structure of net-work, in which few fibroblasts, macrophages and lymphocytes are present. However, polynuclear leucocytes are hardly seen in the meshes. On the side of the medulla, the ependyma is largely destroyed, although it is proliferated in some parts where it remains undestroyed. In the subependymal tissue of the medulla, there are small round cell infiltration and some proliferation of neuroglia, which invades in some places beyond the ependyma into the granulation tissue developing in the peripheral part of the Spongel.

Fig. 3 is the photomicrograph of a phosphotungstic acid hematoxylin preparation of the dog No. 15 with 37 days' survival, in which hyperplasia of neuroglia in the neighborhood of the granulation tissue in the periphery of the Spongel is visible.

(2) 42 days after insertion of Spongel into the fourth ventricle. (No. 28, Fig. 4)

The Spongel is adjacent to the cerebellum upwards and to the pons downwards. Its peripheral part is invaded by fibroblasts, fibrocytes, macrophages and many lymphocytes, and few strands of Spongel frames has already disappeared in this part. A large part of the Spongel except for its periphery preserves a net-work of the original structure, in which meshes lymphocytes, fibroblasts, macrophages and foreign body giant cells are scattered. Hyperplasia of ependymal cells are occasionally seen and cell infiltration and engorgement of blood vessels filled with blood cells are noted beneath the ependyma in the pons.

(3) 63 days after insertion of Spongel into the fourth ventricle. (No. 10, Fig. 5)

The Spongel is bordered by the pons downwards and by the chorioid plexus upwards and encapsulated by a thin layer of granulation tissue developing in its peripheral part. The zone of granulation has become wider than in the preceding two cases and the organization of the Spongel is remarkable around the chorioid plexus and the blood vessels, where appreciable strands of Spongel frames have disappeared and a conspicuous amount of granulation tissue is noted. A few hemosiderin pigmented phagocytes are scattered in the granulation, which invades in some part the meshes of the Spongel towards its center. However, a large part of the Spongel preserves a net-work of the original structure to almost the same extent as in the preceding two cases, although in the latter any cells are nearly absent in the meshes of the Spongel. In the pons small round cell infiltration, engorgement of blood vessels and marked perivascular cell infiltration are found beneath the ependyma.

(4) 58 days after insertion of Gelfoam into the fourth ventricle. (No. 40, Fig. 6)

Similarly to the foregoing cases, the peripheral portion of the Gelfoam is absorbed and replaced with fibrous tissue, which contains fibroblasts, fibrocytes, connective tissue fibers and lymphocytes. Then comes a zone of the granulation tissue, where the Gelfoam shows a fairly well preserved mesh-work. However no strand of Gelfoam frames is seen in its center where it has changed into a homogeneous mass with few fibroblasts and lymphocytes presumably due to the dissolution of the Gelfoam. Hyperplasia of some ependyma cells, cell infiltration and hyperplasia of neuroglia are observed in the pons bordering on the Gelfoam.

(5) 83 days after insertion of Spongel into the fourth ventricle. (No. 8, Fig. 7)

Organization of the Spongel has become more remarkable and a zone of granulation tissue thicker than in case of 63 days' survival. In some parts, granulation tissue extends to the center of the Spongel filling its meshes, but a large part of the center preserves the original net-work, and is free from cells. Organization of the Spongel is most remarkable around the chorioid plexus and the blood vessels. Beneath the ependyma at the level of the pons bordering on the granulation tissue of the Spongel, small round cell infiltration and dilatation of blood vessels filled with blood cells are present.

(6) 108 days after insertion of Spongostan into the fourth ventricle. (No. 35, Fig. 8)

The Spongostan is in contact with the chorioid plexus upwards and with the pons downwards. In its peripheral part some strands of Spongostan frames are lost and replaced by a fibrous tissue, which is seen invading the meshes of the Spongostan as far as to the center. In the central portion of the Spongostan some strands have disappeared and some others have become thinner, whereas still some others preserve the original structure. As subependymal cell infiltration and hyperemia in the pons are slighter in degree than in the preceding cases, an inflammatory reaction caused by a gelatine sponge seems to subside gradually along with the absorption of the gelatine sponge.

(7) 118 days after insertion of Gelfoam into the fourth ventricle. (No. 38, Fig. 9)

The Gelfoam has been absorbed almost completely and replaced by a cicatricial mass. It contains few thin strands of Gelfoam and is smaller in size than in the cases of the following paragraphs (No. 32, and No. 9). In the chorioid plexus overlying the scar tissue epithelial cells are hypertrophied and blood vessels are dilated. Beneath the ependyma in the pons there is a slight increase in neuroglia but neither remarkable cell infiltration nor hyperemia.

(8) 142 days after insertion of Spongel into the fourth ventricle. (No. 32, Fig. 10)

The Spongel has been completely absorbed and a scar mass is formed in its place. Beneath the ependyma in the medulla there is no hyperemia but small foci of round cell infiltration are present.

(9) 218 days after insertion of Spongel into the fourth ventricle. (No. 9, Fig. 11)

The Spongel has been completely replaced by a fairly large connective tissue mass. Capillaries are few in this scar tissue, and cellular elements have become fewer than in the case of 142 days' survival (No. 32). In the superficial layer of the pons under the scar mass some increase in neuroglia is noted but cell infiltration and hyperemia are hardly present. A little amount of the Spongel remains in a very small part of this scar tissue.

Findings of Myelin Sheaths :

In three cases which had been allowed to survive 42, 183 and 270 days respectively, the pons and medulla were examined by Weigert-Pal's myelin sheath stain. Disappearance of myelin sheath was not noted even in the medial longitudinal fascicule situated close to the fourth ventricle. (Fig. 12)

Following the insertion of a gelatine sponge into the fourth ventricle, ependymitis or subependymitis usually appears as a foreign body reaction. Thus, hyperplasia of ependyma, cell infiltration, dilatation of blood vessels filled with blood cells and increase in neuroglia take place in the surrounding brain tissue. On the other hand the gelatine sponge begins to be absorbed and replaced by the connective tissue proliferated from the chorioid plexus and the vessels walls. It is completely encapsulated by granulation by two or three months after its insertion. The granulation proceeds to the center of the gelatine sponge, filling its meshes, and the sponge is almost completely absorbed by four or five months. The absorption of a gelatine sponge takes place more slowly in the fourth ventricle than on the brain surface or within the brain substance, as will be mentioned later. As the flow of the cerebrospinal fluid from the ventricular system to the subarachnoid space is interrupted by the scar tissue formed after the absorption of the gelatine sponge, an obstructive hydrocephalus of various degree results in most of the animals. Along with the process of absorption of the gelatine sponge, the subependymal inflammation gradually subsides and disappears at the final stage, when the gelatine sponge has been completely absorbed and cicatrified. Despite the occurrence of an inflammation in the surrounding brain tissue, a noticeable degeneration of nerve fibers does not seem to result, judging from the result of my study with myelin

sheath stain.

With reference to the mode of absorption and the foreign body reaction there is no essential difference among Spongell, Gelfoam and Spongostan, only that Gelfoam becomes partially homogeneous during the process of absorption (No. 40) and the scar tissue developing after its absorption is smaller than that of the other two preparations (No. 38). As this fact appears to be the result of the different properties of the three preparations displayed when immersed in the cerebrospinal fluid, a dissolvability test in the cerebrospinal fluid has been performed *in vitro*.

Dissolvability Test of Gelatine Sponges in the Cerebrospinal Fluid *in vitro*.

Methods: After putting a piece of each of Spongell, Gelfoam and Spongostan measuring 1 by 1 by 1 cm, into three test-tubes, 4 cc. of the cerebrospinal fluid of a dog is poured in each tube, which is then plugged with paraffin tightly and kept at 37°C for 6 weeks. All procedures should be aseptic.

Results: Gelfoam begins to dissolve one week later. As Fig. 13 shows, after 6 weeks Gelfoam is dissolved almost perfectly leaving only a little sediment, while Spongell and Spongostan are hardly dissolved and keep nearly their original shape and size, there being no difference between the latter two.

(II) Experiment of Insertion of a Gelatine Sponge on the Brain Surface or within the Brain Substance.

Insertion of a gelatine sponge on the brain surface was performed in 6 animals (a-group) and that within the brain substance in 3 animals (b-group). After the operation palsy, vomiting and ataxia were not observed in both groups. There was no choked disc in the animals examined ophthalmologically. In the a-group animals surviving over two months, a fairly dense scar was noted at the site of insertion, adhering to the inside of dura, which seemed to be thickened. The two structures were not distinguishable from each other. When the brain surface had been damaged at insertion, there developed a firm adhesion between the brain surface and the subdural scar. But when the brain had not been damaged, there was no adhesion between them. In all cases of the b-group, dura adhered tightly to the brain surface at the site of insertion of a gelatine sponge. No enlargement of the ventricular system was present in all cases. In 6 animals, in which dural sutures were not possible to make, the defect of dura was covered by another piece of the gelatine sponge from outside. At autopsy, edges of dura were seen to be united perfectly and no fluid leakage was found.

Histological Findings :

(1) 35 days after insertion of Spongell on the brain surface. (No. 29, Fig. 14)

The Spongell is situated between dura and the brain surface, and the organization of the Spongell is more advanced than in the case of the Spongell placed in the fourth ventricle. Strands of Spongell has disappeared in its peripheral part mainly on the side of dura and in some places the granulation tissue, arising from

dura, is extending to the center of the Spongel. In the meshes of the Spongel many lymphocytes, fibroblasts, macrophages and few foreign body giant cells are present. A boundary between dura and the granulation tissue is obscure, while the Spongel is separated by pia mater clearly from the cortex. Cell infiltration and hyperemia are hardly noted in the cortex bordering on the Spongel.

(2) 47 days after insertion of Spongostan on the brain surface. (No. 26, Fig. 15)

The Spongostan has been absorbed almost completely and a dense scar developing after its absorption is found. There is a narrow free space between the brain surface and the scar tissue, whereas the scar is continuous to dura.

(3) 43 days after insertion of Spongel within the brain substance. (No. 20, Fig. 16)

The organization of the Spongel is more advanced in the part which is nearer to the brain surface. Granulation tissue extends from the brain surface into the brain substance deeply, and the Spongel has already been absorbed near the brain surface. In the deeper part of the brain the organization is taking place in the peripheral zone of the Spongel in contact with the brain parenchyma and the Spongel is encapsulated by a thin wall of granulation, which is invading the Spongel in places even to its center. In this granulation tissue there are hemosiderin pigmented phagocytes which are scattered near the brain surface but grouped in the deeper part. A slight hyperplasia of neuroglia is noted in the brain substance adjacent to the granulation tissue around the spongel.

The absorption of a gelatine sponge takes place for more rapidly on the brain surface than in the fourth ventricle. It is absorbed completely by about two months after insertion. The organization of a gelatine sponge is initiated from the inside of dura and the scar developing after its absorption is as dense as that seen in the fourth ventricle. If a gelatine sponge is placed on the uninjured brain surface, there occurs no adhesion between the scar and the brain surface. Thus the cortex is separated by pia mater from the gelatine sponge and presents hardly inflammatory changes. However in case when gelatine sponge is inserted within the brain substance, granulation tissue develops mainly from the brain surface and then proceeds towards the deeper part and the organization is completed in a much shorter time than in the case of a gelatine sponge in the fourth ventricle. Among the three preparations of the gelatine sponge, there is no difference in the foreign body reaction, the rapidity of absorption and the amount of scar formed, and Gelfoam never becomes homogeneous as a result of dissolution.

COMMENT

The gelatine sponge seems to be absorbed chiefly by the action of macrophages, because macrophages and lymphocytes were noted in its meshes, which remained undissolved for a long time. This is in accord with the finding of Jenkins who studied on the absorption of a gelatine sponge in the liver, kidney and spleen.

If the result of my experiments, in which a gelatine sponge was inserted on the brain surface or within the brain substance, is compared with that of the similar

experiments of Light, the absorption of the gelatine sponge took place more slowly in mine than in the latter. It seems a matter of course that there should be some difference between the two, because I used a larger amount of the gelatine sponge twisted into a string in dry state.

In my experiment a gelatine sponge inserted into the fourth ventricle was absorbed by the organization in the same way as on the brain surface or within the brain substance. In the amount and density of scar developing in each of these three sites of insertion, there was no difference. However, a remarkable difference was present in the rapidity of absorption, which was in the following order; (1) on the brain surface, (2) in the brain substance and (3) in the fourth ventricle. In the fourth ventricle, the organization of a gelatine sponge began around the chorioid plexus and the blood vessels; on the brain surface, from the inside of dura; and in the brain substance, from the brain surface. No organization did occur at any place without a mesodermal tissue and a different amount of the mesodermal structure seems to be responsible for the difference in the rapidity of absorption in the three sites.

Light and Jenkins et al stated that a gelatine sponge did not cause a remarkable inflammatory tissue reaction. However, in my experiments a considerable inflammatory reaction was observed lasting for a fairly long time, especially in the fourth ventricle.

We must evaluate the usefulness of a foreign body like a gelatine sponge, which is, though absorbable, left in place after operation, by the following three criteria; viz, the foreign body reaction in tissue, the rapidity of absorption and the degree of scar formation. Concerning the former two, no remarkable difference is noted among Spongel, Gelfoam and Spongostan. However, the amount of scar produced is less in Gelfoam than in the others. In this respect, Gelfoam is the best. A portion of Gelfoam inserted into the fourth ventricle becomes homogeneous due probably to the dissolution in the cerebrospinal fluid, as has been evidenced in the test in vitro, in which the dissolution of Gelfoam in the cerebrospinal fluid has been found far greater than that of the others. Less scar formation successive to the absorption of Gelfoam may result chiefly from such a rapid dissolvability. It is said that blood clotting is hastened by the liberation of thromboplastin when the platelets in the blood entering the gelatine sponge become damaged by contact with the walls of the myriads of interstices, which present a rather large surface area, and that strands of the gelatine sponge give structural support to the clot. A gelatine sponge is an insoluble but absorbable gelatine converted purposely from a soluble gelatine, because it has been presumed that a sponge must remain insoluble during some period for the purpose of hemostasis. However, it may be said from my experiments that a material, which dissolves to a certain degree, is better for the use in the brain, where a mesodermal response is usually poor and a scar formation should be as slight as possible.

According to Ford (cited from Moritz), it is possible that the aqueduct of Sylvius may be plugged by blood clot or bits of necrotic brain tissue which become

organized and a progressive hydrocephalus ensues. A similar obstructive hydrocephalus was observed in this experiment. The flow of the cerebrospinal fluid from the ventricular system to the subarachnoid space was disturbed by a scar mass in the fourth ventricle produced by the organization of a gelatine sponge. This fact should always be born in mind and the use of a gelatine sponge in an unnecessarily large amount in a ventricle (as well as in the depth of the brain substance) is to be avoided. In my experiment it was also shown that a dural defect healed excellently when covered with a piece of the gelatine sponge from outside. Such may be another proper use of a gelatine sponge in neurosurgery.

CONCLUSIONS

In the present experiment, a gelatine sponge has been inserted into the fourth ventricle in a group of dogs to investigate how it is absorbed there. A gelatine sponge has also been introduced on the brain surface or within the brain substance in other groups of dogs in order to compare its absorbability in the three different sites. Conclusions are as follows.

(1) A gelatine sponge inserted into the fourth ventricle is absorbed with organization in the same way as in other tissues. The organization of the gelatine sponge begins mainly around the chorioid plexus and the blood vessels, and its absorption takes place more slowly in the fourth ventricle than on the brain surface or within the brain substance. The rapidity of absorption may depend chiefly on the amount of the mesodermal tissue in the region where the sponge has been inserted.

(2) As the flow of the cerebrospinal fluid from the ventricular system to the subarachnoid space is interrupted by the scar mass developing in the fourth ventricle after the absorption of a gelatine sponge, an obstructive internal hydrocephalus usually results.

(3) The amount of residual scar mass is the least in Gelfoam among the three gelatine sponge preparations examined. In this respect Gelfoam is superior to Spongel and Spongostan. The reason may be in the fact, that Gelfoam dissolves in the cerebrospinal fluid more easily than the other two.

(4) A gelatine sponge causes an inflammatory or a foreign body reaction to a certain degree in the surrounding brain tissue.

(5) By an analogy with the occurrence of an internal hydrocephalus following insertion of a gelatine sponge into the fourth ventricle, it may be understood how an obstructive internal hydrocephalus develops following a brain injury with bleeding into the ventricular system.

(6) Because of the occurrence of a foreign body reaction and an excessive scar formation, the amount of a gelatine sponge must be as little as possible, when it is used for hemostasis in the brain, especially within a ventricle.

Fig. 7

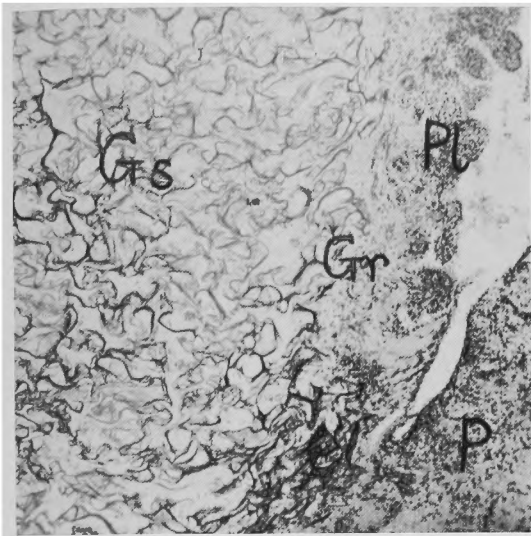


Fig. 10

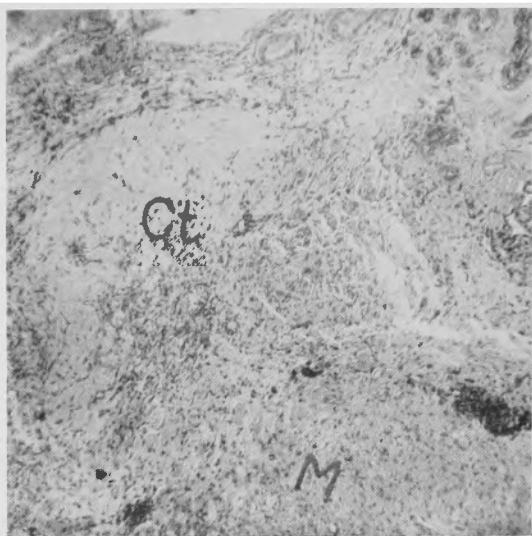


Fig. 8

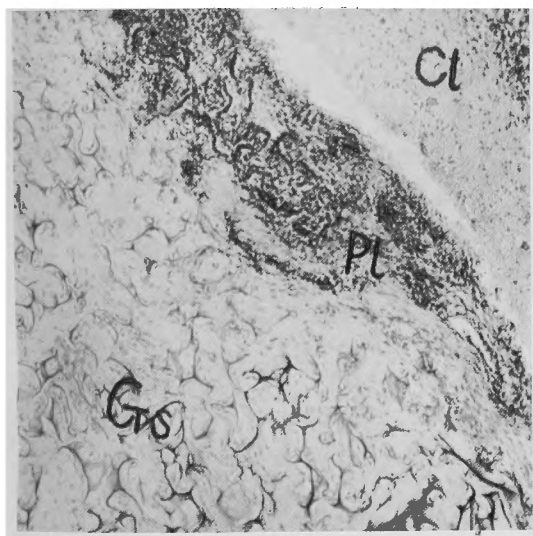


Fig. 11

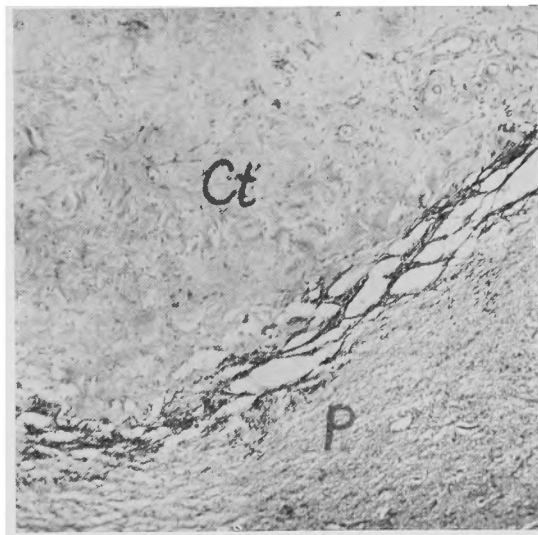


Fig. 9

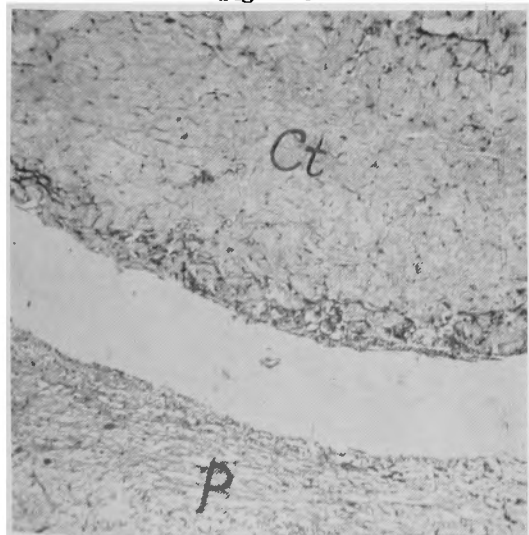


Fig. 12

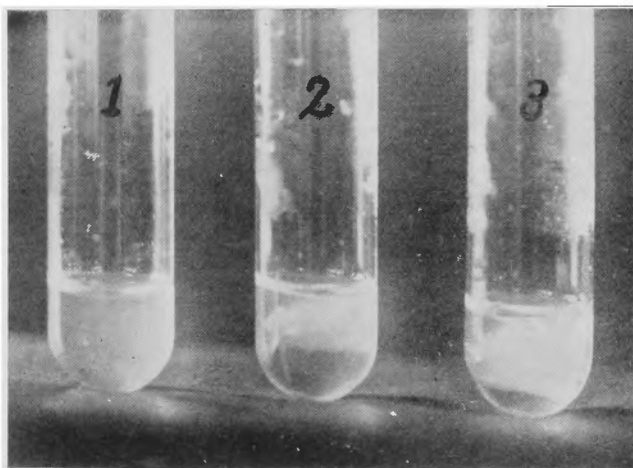


Fig. 13



Fig. 15

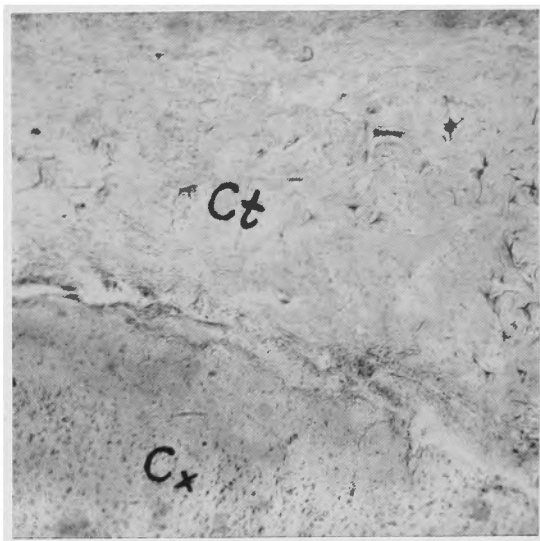


Fig. 14

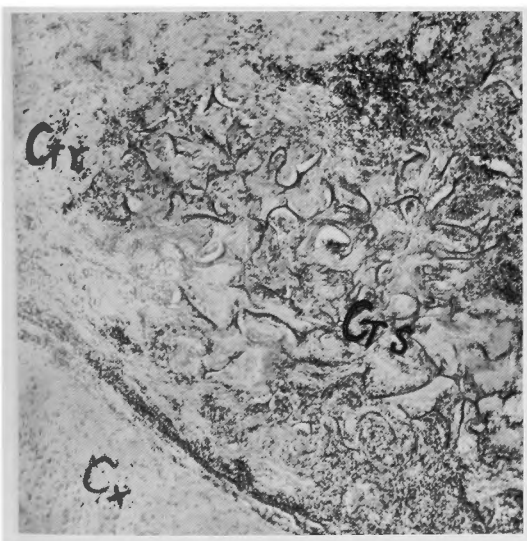
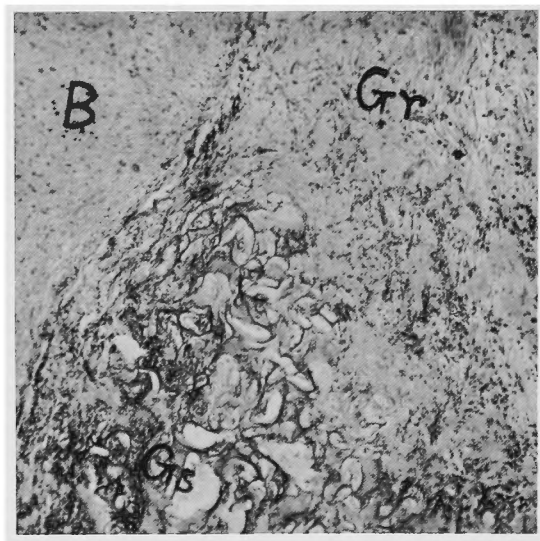


Fig. 16



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EXPLANATION OF PLATFS

- Fig. 1.** Frontal section of the brain at the level of tuber cinereum of the dog No. 32 with 142 days' survival. A remarkable enlargement of the third and the lateral ventricle. The brain on the right side is the normal control.
- Fig. 2.** 31 days after insertion of Spongel into the fourth ventricle. A thin zone of organization is seen in the peripheral part of the Spongel. (H. E. stain $\times 100$)
- Fig. 3.** 37 days after insertion of Spongel into the fourth ventricle. A slight increase in neuroglia is visible in the pons. (Phosphotungstic acid hematoxylin stain $\times 400$)
- Fig. 4.** 42 days after insertion of Spongel into the fourth ventricle. (H. E. stain $\times 100$)
- Fig. 5.** 63 days after insertion of Spongel into the fourth ventricle. In the pons, a remarkable perivascular cell infiltration is seen. (H. E. Stain $\times 100$)
- Fig. 6.** 58 days after insertion of Gelfoam into the fourth ventricle. The center of the Gelfoam shows a homogeneous appearance and no strand of the Gelfoam can be seen. (H. E. stain $\times 100$)
- Fig. 7.** 83 days after insertion of Spongel into the fourth ventricle. Granulation tissue is seen around the chorioid plexus. (H. E. stain $\times 100$)
- Fig. 8.** 108 days after insertion of Spongostan into the fourth ventricle. Granulation tissue, developing from the chorioid plexus, invades the meshes of the Spongostan (H. E. stain $\times 100$)
- Fig. 9.** 118 days after insertion of Gelfoam into the fourth ventricle. The space between cicatricial tissue and the pons is artificial. (H. E. stain $\times 100$)
- Fig. 10.** 142 days after insertion of Spongel into the fourth ventricle. A residual cicatricial tissue, formed after absorption of the spongel. (H. E. stain $\times 100$)
- Fig. 11.** 218 days after insertion of Spongel into the fourth ventricle. A dense cicatricial tissue. (H. E. stain $\times 100$)
- Fig. 12.** 183 days after insertion of Spongel into the fourth ventricle. Loss of myelin sheath is lacking. (Weigert-Pal's stain $\times 50$)
- Fig. 13.** Dissolvability test of gelatine sponges in the cerebrospinal fluid in vitro. 1: Gelfoam, 2: Spongel, 3: Spongostan. Gelfoam is dissolved almost perfectly.
- Fig. 14.** 35 days after insertion of Spongel on the brain surface. Many cells invade the meshes of the Spongel and appreciable strands of the Spongel are absorbed. (H. E. stain $\times 100$)
- Fig. 15.** 47 days after insertion of Spongostan on the brain surface. The Spongostan is absorbed almost completely. (H. E. stain $\times 100$)
- Fig. 16.** 43 days after insertion of Spongel within the brain substance. The strands of the Spongel are absorbed in the portion near to the brain surface. (H. E. stain $\times 100$)

Gs : gelatine sponge.

Ct : cicatricial tissue.

Gr : granulation tissue.

Cl : cerebellum.

Pl : chorioid plexus.

Cx : cortex.

P : pons.

mlf : medial longitudinal fascicule.

B : brain substance.

M : medulla oblongata.

和文抄録

犬の第四脳室内に挿入したゼラチンスポンジは
如何に吸収されるか？

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精製可吸収性ゼラチンスポンジの三種製剤 Spongell (山之内製薬), Gelfoam (Upjohn 社) 及び Spongostan (Ferrosan 社) を成熟犬の第四脳室内に挿入しその吸収状態を比較検索し、併せて脳表面、脳実質に於ける吸収状態と比較し次の如き結論を得た。

1. 第四脳室内に挿入されたゼラチンスポンジは他組織に於けると同様に器質化により吸収され、器質化は脈絡叢周囲、血管周囲より起り、吸収は脳表面、脳実質に於けるより緩かである。これは主として脳室に於ける間葉系の組織分布の少いことによると考えられる。

2. 第四脳室内にゼラチンスポンジを挿入すると吸収後生ずる瘢痕組織により髄液の蛛網膜下腔への流れが障碍され閉塞性内脳水腫を惹起した。

3. 第四脳室内にゼラチンスポンジを挿入した場合、あとに生じた瘢痕組織の点では Gelfoam が他の二製剤より優つており、これは Gelfoam が髄液に溶解するためと考えられる。

4. ゼラチンスポンジには異物としての刺激性がかなりあり周囲脳組織に炎症を惹起した。

5. 脳外傷時の脳室系への出血後に見られる内脳水腫の発生機転は第四脳室内ゼラチンスポンジ挿入後惹起された内脳水腫の成立より類推し得る。

6. ゼラチンスポンジには周囲組織に対する異物としての刺激性があり且吸収後かなり強い瘢痕組織を生ずる点より見て臨床上開頭術に於ける止血にゼラチンスポンジを用いる際には可及的小量を使用すべきと考える。